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Expected Comet of 1264 *and* 1556.

For information respecting this comet, and for ephemerides on the hypothesis of different times of perihelion passage, see Mr. Hind's pamphlet, *On the expected Return of the Great Comet of* 1264 *and* 1556, by J. R. Hind, 8vo. pp. 78. London, G. Hoby, 123 Mount Street, Berkeley Square.

Parabolic Elements of the First Comet of 1847. By Mr. Pogson.

The following orbit is calculated upon the observation at Mr. Bishop's observatory on February 7th, the daylight positions obtained at the same observatory on March 30, and the Berlin observation of April 24; thus embracing the whole period of visibility. The elements of this comet appear to differ sensibly from a parabola:—

T 1847, March 30·27725, Greenwich Mean Time.

	° ′ ″	
ϖ …………	276 2 43·7	Mean Equinox, 1847·0
☊ …………	21 42 45·3	
i …………	48 39 33·6	
Log. *q* ……	8·628571	

Motion direct.

Corrections of the Elements of the Moon's Orbit, deduced from the Lunar Observations made at the Royal Observatory of Greenwich, from 1750 *to* 1830. By G. B. Airy, Esq., Astronomer Royal.*

"The reductions of the Greenwich Lunar Observations, lately published by the Lords Commissioners of the Admiralty, present the results of a series of observations, to which scarcely any thing similar exists, and to which nothing similar can be furnished for many years to come. The whole number of observations of right ascen-

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* The title of the work referred to in Mr. Airy's Memoir is *Reduction of the Observations of the Moon, made at the Royal Observatory, Greenwich, from* 1750 *to* 1830. *Computed by order of the Lords Commissioners of the Treasury, under the superintendence of G. B. Airy, Esq., M.A., Astronomer Royal. Published by order of the Lords Commissioners of the Admiralty.* London, 1848. 2 vols. 4to.

The Lords of the Admiralty, with their wonted liberality, have placed a large number of copies of this important work at the disposal of the Royal and of the Royal Astronomical Societies. It is understood that they will be presented to those public bodies and scientific gentlemen to whom the Greenwich Observations are given. As there is a difficulty in transmitting such articles, it is requested that application should be made for them at the apartments of the Society, or at least that information should be given as to the most convenient channel. It is proper to mention here, what might otherwise probably be unnoticed, that the Reduction of the Greenwich Lunar Observations is due to the suggestion of the Astronomer Royal himself, and that his direction and superintendence have been gratuitous. This was also the case with the Greenwich Planetary Reductions, published two or three years ago.

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sion of the moon which are thoroughly reduced is 9067. Of these 674 are not accompanied by trustworthy observations in north polar distance (the observations being sometimes wanting, sometimes inaccurate in character, as in the method of observation called *per segmentum*, and sometimes vitiated by the faults of adjustment of the quadrant): leaving 8393 observations, complete in both elements, and as good as the nature of the instruments permitted. All these observations are used in the investigations which form the subject of this paper. These observations have been reduced with a labour proportionate to their importance. Much care has been used in planning the form of the reductions, and no pains have been spared in insuring their accuracy in every detail. The results are exhibited in a form which makes it comparatively easy for any person occupied with empirical reductions from observations to investigate the co-efficient of any inequality of any periodic time whatever. I trust, therefore, that the utility of these reductions will not be limited to the investigation of the corrections which I now beg leave to lay before the Royal Astronomical Society.

"The deductions from the reduced observations which have the first claim on our attention are, evidently, the corrections of those elements which enter as arbitrary constants in the mechanical theory of the moon's motion, and the corrections of the most important results of theory, on which, from the slowness of convergence of series, or from the practical difficulty of picking up every sensible term, some doubt may yet exist. The former are, the moon's epoch of longitude and mean motion, the excentricity and epoch of anomaly, and the inclination and epoch of argument of latitude. The latter are, the motion of anomaly (depending on the progression of the apse), the motion of argument of latitude (depending on the regression of the node), the variation, the evection, and the annual equation. But there are also other terms which demand particular attention, as depending upon other elements which are not of an arbitrary character, though their values are not precisely known. These are the equations of long period in the longitude and in the elements of latitude of the moon (depending on the ellipticity and internal constitution of the earth), the parallactic equation (depending on the proportion of the moon's mean distance to the sun's mean distance), and the constant term of the moon's parallax (depending in part on the proportion of the moon's mass to the earth's mass). All these terms are clearly pointed out by the nature of the case as demanding our first attention in the discussion of the reduced observations.

"In preparing the last section of the printed work, the importance of these deductions was kept in view. Through every part of the tabular exhibition of the comparison of observed and theoretical places of the moon, there are exhibited the corresponding values of the principal inequalities affecting the moon's place in every observation, each increased by a constant for the purpose of making it always positive. In the comparison of observed and theoretic longitudes the quantities thus exhibited are, (1), The Elliptic Inc-

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quality; (2), Its change for a change of $0^{g}\cdot 1$ ($\frac{1}{4000}$ part of the circumference) in argument; (3), The Parallactic Inequality; (4), The Variation; (5), Its change for a change of $0^{g}\cdot 1$ in argument; (6), The Annual Equation; (7), The Evection; and (8), Its change for a change of $0^{g}\cdot 1$ in argument. Of these, the 5th is necessary only in case the correction of moon's longitude should be very large; and the 8th is necessary only in combination with the 2d, as the argument of evection is necessarily dependent on the argument of elliptic inequality. In the comparison of observed and theoretical ecliptic north polar distance, the quantities exhibited are (9), The Effect of mean Inclination; (10), Its change for a change of $0^{g}\cdot 1$ in argument; (11), The Evection in Ecliptic North Polar Distance. The equations of long period in the longitude and in the elements of latitude are not exhibited, because the corrections of those equations can be deduced by a simple process from the corrections of the other quantities, when the latter are determined from groups of observations whose divisions have respect to the changes of the equations of long period. The effects of alterations in the mean motions of longitude, of anomaly, and of argument of latitude, are not exhibited, because the corrections of these quantities can be deduced from the values of the corrections of epoch, of anomaly, and of argument of latitude, obtained at distant times.

"Omitting the effect of errors in all inequalities except those I have mentioned, every comparison gives an equation of condition in which the inequalities under consideration enter with their proper coefficients.

"The theoretical longitudes and ecliptic north polar distances with which the observed longitudes and ecliptic north polar distances are compared, are computed by Plana's theory, as far as regards the terms retained and their co-efficients (on which the most ample information will be found in the introduction to the *Reduction of Lunar Observations*), and from Damoiseau's tables as far as regards epochs and mean motions of every kind. Corrections to co-efficients must, therefore, be applied to Plana's co-efficients, and corrections to epochs and mean motions must be applied to Damoiseau's epochs and mean motions."

The Astronomer Royal remarks, that the most legitimate mode of solving these equations of condition would be by the method of least squares; but the enormous trouble, the chance of numerical errors, and the necessity of checking the processes of calculation, have induced him to prefer the selection of groups, in which each unknown quantity enters with its positive or negative values. The immense number of recurrences of the incommensurable periods of the various equations running through such a long time makes this process very satisfactory, except in the case of variation and parallactic equation, of which the arguments depend on the difference of mean longitude between the sun and moon. As there are very few observations near conjunction, a modification is adopted in the mode of grouping the equations for those inequalities, which is a

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good approximation to the method of least squares. The several groups of equations, with their respective solutions, are then given.

The Astronomer Royal then proceeds to shew in detail, how from his groups of equations the corrections of various constants are obtained. In some cases the observations shew a form not yet indicated by theory.

We have here only room for the results of this skilful handling of such apparently unmanageable masses.

1.[*]

Correction of Moon's Epoch of Longitude and Mean Motion.

Epoch of mean longitude, 1814 Jan. 1, 0^h Greenwich mean time	44^g	23'	98''·2
Motion in 365 days	143	76	08 ·88
Motion in 100 Gregorian years	327	45	86 ·20

2.

Equation depending on the elliptic form of the earth.

The whole of this inequality, the argument of which is the mean place of the moon's node, is

$$+6''{\cdot}35 \text{ sin. long. moon's node } -0''{\cdot}97 \text{ cos. long. moon's node.}$$

The latter term is not recognised by theory, but its existence does not admit of doubt. The value seems well ascertained.

3.

Equation of the centre.

Coefficient of the sin. mean anomaly when the true longitude is expressed in a function of the mean longitude, as in Damoiseau's form............	$=22639''{\cdot}14$

Also the correction to the moon's longitude =

$$\{-0''{\cdot}31 \text{ cos. long. node } +0''{\cdot}94 \text{ sin. long. node}\} \text{ sin. mean anomaly.}$$

4.

Correction of the epoch and motion of mean anomaly.

True epoch of anomaly for 1788, Jan. 1, 0^h Greenwich mean time	=	110^g	59'	47''
Motion of anomaly in 100 Gregorian years which appears very certain	=	206	39	80

The corrections to the moon's longitude =

$$\{+0''{\cdot}19 \text{ cos. long. node } +1''{\cdot}65 \text{ sin. long. node}\} \text{ cos. mean anomaly.}$$

5.

Small terms depending on combinations of the mean anomaly and the longitude of node.

They may be put under this form :

$$+0''{\cdot}66 \text{ sin. (mean anom.} + \text{long. node)} - 0''{\cdot}38 \text{ cos. (mean anom.} + \text{long. node)}$$
$$-0\ {\cdot}98 \text{ sin. (mean anom.} - \text{long. node)} + 0\ {\cdot}56 \text{ cos. (mean anom.} - \text{long. node)}$$

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[*] When the correction is to be applied to Damoiseau, it is given in *grades*, &c.; *i. e.* the circumference is divided into 400 grades, each grade into 100 parts, marked ', and each 1' into 100 parts marked 1''. This notation will be a sufficient guide.

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6.

Correction of the coefficient of parallactic equation.

Corrected coefficient = 122″·37, but this is uncertain.

An empirical inequality would render the observations more accordant, but this has no probable physical foundation. The more likely cause for the observed irregularities is a change in the estimation of the moon's semi-diameter, depending on changes in the telescope or in the observer. From the law of the inequality this coefficient will always be somewhat uncertain.

7.

Correction of the coefficient of variation.

Corrected coefficient = 2370″·98, which is somewhat uncertain, as depending in part on the estimated semi-diameter of the moon.

8.

Correction of the coefficient of annual equation.

True coefficient = 670″·29, pretty certain.

9.

Correction of the coefficient of evection.

True coefficient = 4586″·88, very certain.

10.

Determination of the correction to the constant term of parallax, remarks on the latitude of Greenwich, and on subjects related to it.

The Astronomer Royal here enters into a discussion which cannot be made intelligible if compressed.

The *whole* of the observations shew an error in the constant term of horizontal parallax, *i.e.* that it should be increased by 1″·78: the constant term would in this case be 3424″·94.

But the earlier and the later groups give different values of this correction, and again the colatitude in the earlier and later reductions is differently assumed. For the first 15 years, Bessel's colatitude, 38° 31′ 20″·40, was adopted, and for the last 16 years Airy's, 38° 31′ 21″·93, or somewhat more. Between these periods the colatitude may be said to have been assumed to increase uniformly, for Olufsen's index-errors of the quadrant, which have been followed, are obtained by comparing the places observed with those of the *Tabulæ Regiomontanæ*, which are interpolated between Bradley's places, colatitude 38° 31′ 20″·40, and Bessel's, which agree with those obtained by a latitude somewhat greater than 38° 31′ 21″·93.

The Astronomer Royal rejects the hypothesis of a real change in the colatitude owing to *partial* disturbances in the earth, as contradicted by the geological character of the country; and a change in the direction of the vertical from a *general* cause would disturb the sea-level in some parts of the world 100 feet. Neither is it possible, as he shews, from the admirable accordance of various modern observations, that any error can exist in the modern latitude of Greenwich. The solution of the difficulty is probably to

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be found in the original imperfections of the Greenwich Quadrant,* and in its gradual degradations.

The Astronomer Royal, after proposing the best hypothesis of error which he can suggest, and bringing the later Cambridge and Greenwich observations to bear on the subject, concludes by saying, that probably Plana's constant term of parallax should be a little increased, and the moon's mass be correspondingly diminished. He proposes in the future reductions at Greenwich to increase Burckhardt's parallax by $\frac{1}{1200}$ part.

11.

Correction of the inclination of the moon's orbit: terms of long period in the inclination of the moon's orbit.

Inclination of the orbit $= 18535''\cdot46$, very certain.

Inequalities of long period $=$

$-0''\cdot82$ cos. long. node $-2''\cdot02$ sin. long. node.

12.

Correction of the argument of latitude, and of the motion of the argument: terms of long period in the argument.

Epoch 1782, Jan. 1, 0^h Greenwich mean time, Argument of latitude .... $= 117^g\ 70'\ 14''$

Motion in 100 Gregorian years .... $= 76\ \ 44\ \ 12$

Inequalities in argument of latitude $=$

$+25''\cdot71$ cos. long. node $-7''\cdot56$ sin. long. node.

13.

Small terms in the moon's latitude produced by the combination of the small terms of long period in the inclination and in the argument of latitude.

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* Mr. Airy says, "Science is not always progressive; and this remark applies with great force to the construction of astronomical instruments. Long ago Roemer proposed a circle almost precisely similar to that now mounted in the Oxford Observatory. Flamsteed's mural arc, extending from the pole to the south horizon, was one step backwards. The Greenwich mural quadrant, scarcely extending beyond the zenith, was another and an enormous step backwards. The artistical talents of Graham and Bird, which, by the perfection that they introduced in the details of their instruments, gave popularity to a construction that is radically bad, may be considered as the greatest misfortune that has happened to astronomy. They undoubtedly retarded the progress of accurate astronomy for half-a-century." These remarks are unquestionably true, and it is difficult to conceive how Roemer's discoveries and successful practice should have been so much overlooked; but surely the persons to blame are the successive *Astronomers Royal*, Halley, Bradley, and Maskelyne, whose business it was to direct the kind of instrument to be constructed, and not to trust implicitly to the artist. Halley introduced the transit after Roemer, with whom he probably was acquainted. Horrebow's book, which appeared in 1735, must have been known to Bradley and Maskelyne. As it is in Latin, we might excuse the artists more completely if it were not illustrated with very tolerable plates.

As a confirmation of the remark of the Astronomer Royal, we may mention here that the solstitial circle described by Ptolemy, and probably invented by Eratosthenes, bears a close resemblance to the Greenwich mural circle; and that all the practical astronomers after this time seem to have misunderstood the proper construction of their tools till Roemer.

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Neglecting two insignificant terms, and combining the rest with the term $-8''{\cdot}00$ sin. u, adopted in the theoretical calculations, the inequality depending on the earth's figure =

$$+2''{\cdot}17 \text{ cos. } u \quad -8''{\cdot}75 \text{ sin. } u.$$

The first term is not recognised by theory, but its existence is undoubted, and the magnitude approximate.

14.

Correction of the coefficient of evection in ecliptic north polar distance.

The corrected coefficient appears to be $527''{\cdot}26$, but the probability that this is more accurate than the present coefficient, $527''{\cdot}5$, is very small.

"The deductions which have here been drawn from the *Reduced Lunar Observations* are probably all that can be inferred from the annual groups which are printed at the end of that work. For examining into the existence or corrections of terms with different arguments, it will be necessary to refer to the individual observations as reduced. This operation will never be very laborious.

"An examination of the equations in the earlier part of this paper will shew that, in each equation, every term (except that which has been expressly formed with a large coefficient,) might have been neglected, without introducing important inaccuracy into the determination of the one unknown quantity affected by that large coefficient. In other words, when the changes of sign of an inequality are determined, it is only necessary to group the values of "excess of observed longitude," or "excess of observed ecliptic north polar distance," omitting all other numbers. The process therefore will be, assuming the inequality to depend upon the sine, to determine all the times when the argument has the values 0^g and 200^g; and, finding the mean of all the "excesses" between 0^g and 200^g, and the mean of all the "excesses" between 200^g and 400^g, to subtract the latter from the former, and to multiply the difference by $\frac{\pi}{4}$. If the inequality depend upon the cosine, the divisions of groups must be made for arguments 100^g and 300^g. If two arguments are closely related, it may be necessary to use some extraordinary caution, in the same manner as for the annual equation and variation."

Mr. Maclear has sent "the mean places of the 65 stars compared with Mauvais' second comet (*Mem.* R.A.S. vol. xv. pp. 244–7), together with their apparent places on the day of comparison."

"The stars compared with the comets of Wilmot and Gambart have been observed, and the reductions are in a forward state. These and the observations of Gambart's comet will be transmitted in the course of next month. The observations of *Neptune* will follow as soon as they can be got ready. The list of stars which Professor Mädler requested to have observed is nearly ready."